IN SITU CONSTANT MASS FLUX AIR PERMEABILITY TESTING USING PNEUMATIC PACKERS

PROCEDURE ID: YMP-LBNL-TIP/AFT 4.0 | REV. 1, MOD. 0 | EFFECTIVE:01/21/2000

1. PURPOSE

The objective of this procedure is to ensure that in-situ scale air permeability tests are performed, and that the data from these tests are generated, in a well-documented and repeatable fashion that conforms to and is appropriate for the needs of scientific investigators and the Lawrence Berkeley National Laboratory (LBNL)Yucca Mountain Site Characterization Project (YMP) quality assurance requirements.

This procedure describes the process by which air permeability measurements shall be taken. It describes what equipment shall be used and how this equipment shall be managed and utilized to obtain the measurements. It describes what data shall be taken and how it shall be recorded during an air permeability measurement. It also describes how to determine if the data acquired is acceptable or not acceptable and how a record of this acceptability shall be kept.

2. SCOPE

This procedure applies to all LBNL personnel (or contractor personnel following LBNL procedures) involved in YMP activities whenever they are required to perform constant mass flux air permeability measurements or measurements in a borehole or boreholes in the field, including but not limited to, boreholes in niches and alcoves, that do not have a specific Technical Implementation Procedure (TIP) of their own. These activities are subject to Quality Assurance Requirements and Description (QARD), DOE/RW-0333P.

For all technical activities, data collected using this procedure and any equipment calibrations or recalibrations that may be required shall be in accordance with this TIP and in full compliance with YMP Administrative Procedure (YAP)-12.3Q, *Control of Measuring and Test Equipment and Calibration Standards.* Documentation resulting from actions taken under this TIP shall be recorded in Scientific Notebooks as described in the Office of Civilian Radioactive Waste Management (OCRWM) Administrative Procedure (AP)-SIII.1Q, *Scientific Notebooks*. Measurements and calibrations of other equipment not specifically mentioned herein shall be in full compliance with YAP-12.3Q. Electronic data maintenance, controls and transfers shall comply with YMP-LBNL-Quality Implementing Procedure (QIP)-SV.0, *Control of the Electronic Management of Data.*

If this procedure cannot be implemented as written, YMP-LBNL personnel shall notify the responsible Principal Investigator (PI) or designee. If it is determined that a portion of the work cannot be accomplished as described in this TIP, or would produce undesirable results, that portion of the work shall be stopped and not resumed until this procedure is modified per YMP-LBNL-QIP-5.2, *Preparing Development Plans & Quality /Technical Implementing Procedures*.

If the responsible PI or designee determines that a modification or a revision to the TIP would cause an unreasonable delay in proceeding with the task, then an expedited change to the procedure, including documentation of deviation from the approved procedure, can be made according to YMP-LBNL-QIP-5.2. Such changes are subject to review, usually after the task has proceeded, and thus work performed under TIPs with expedited changes is done at risk of future invalidation.

Employees may use a controlled electronic or hard copy of this procedure; however, employees are responsible for assuring that the correct revision of this procedure is used. When this procedure becomes obsolete or superseded, it shall be destroyed or marked "superseded" to ensure that this document is not used to perform work.

3. PROCEDURE

A reference to this procedure and the information obtained through its use shall be recorded in the scientific notebook in accordance with AP-SIII.1Q, for each set of tests. A set of tests is defined for the purposes of this document as tests that are of similar type and configuration using approximately the same equipment that are run at one site. Any section of borehole that is isolated from the outside by a packer is referred to as a zone.

3.1 General Test Methodology

A constant mass flux permeability (air permeability test) test is performed by injection of clean air or extraction of ambient air with or without trace gas at constant mass flow rate between two inflated packers in a borehole or between one inflated packer and the end or bottom of the borehole while flow rate and pressure are recorded. The air permeability of the rock under test can then be obtained from the pressure change and the flow rate using a formula appropriate for the type and geometry of the test. The exact type of test shall be documented in the scientific notebook for each set. A set of tests shall contain tests all of the same variety, unless different varieties are part of a systematic approach that is documented in the scientific notebook as such. The time-scale of each test shall be appropriate to the desired results and physical scale of the tests. For example, tests between boreholes on the top of Yucca Mountain might take several months while tests

between rockbolt holes in a niche might take several minutes, both scenarios dependent on whether only transient data is of interest or if steady state data is the primary focus.

3.2 Air Permeability Instrumentation

The general scheme for instrumentation for air permeability tests involves the use of mass flow controllers (MFCs) to control the mass rate of air being injected or suctioned through a tube into the injection/suction zone. A pressure transducer is used to measure the pressure response in the injected (or suctioned) and any other zones. Pressure transducers can communicate with a given zone by means of tubing run through the packer assemblies or by mounting the instrument downhole and sending its electrical signals through wiring. A single transducer may be used for measuring more than one zone by having its tubing redirected to alternated zones to make measurements. The tube used by pressure transducers must, unless specifically noted in the scientific notebook, be separate from that used for injection or suction because dynamic pressure drop in the injection or suction tube can cause pressure change in this line that is not associated with the permeability of the zone. If the requirement for separate tubes cannot be met (e.g. due to space constraints), then the tube length, tube internal diameter, and flow rate between the point of pressure measurement and the exit or entrance point for the air at the zone shall be recorded in the scientific notebook.

3.3 Air Permeability Packers

Packers are inflatable rubber bladders that can be inflated with air to seal sections of a borehole. Packers may be individually supported by internal structure or connected together in series on one long structure to create a single string with multiple packers. The rubber shall be thick enough, to ensure that it's strength is adequate to withstand the inflation pressure.

3.3.1 Once employed in the borehole, record the location of each sealing end of each packer in the notebook. The actual seal location can only be estimated from the constructed dimensions, the borehole diameter, and the inflation pressure of the packer and is difficult to verify once the packer is inflated in the borehole. It is sufficient to record the construction dimensions of the packers or packer string once and then record the location of a particular point on the string each time it is installed in a borehole for the purposes of testing.

3.3.2 Ensure that the packer inflation pressure is low enough that the packer does not deform to the point at which it will rip or cover up part of the designated injection or suction zone.

3.3.3 Ensure that inflation pressure is high enough so that the packer seals the designated sealing zone against leak-by of the injected or suctioned air and provides the predicted length of sealing zone in the borehole. The length of this sealing zone is determined for a given packer construction and inflation pressure by inflating the packer in clear tubing of the same diameter as the borehole while observing the contact length. The inflation shall also cause the packer not to be movable by hand within the hole. Document the actual inflation pressure in the scientific notebook.

3.3.4 Check packers for correct inflation before any alteration of the inflation or configuration during testing and again after testing.

3.3.5 Each packer shall be verified not to leak at the rubber by closing its inflation valve for the period of interest either during testing or after testing, and recording the pressure sustained by the packer at the end this period. Inflation pressure shall be close enough to the original value to still ensure correct sealing and geometry. This shall be verified and recorded with time and date as such in the scientific notebook.

3.4 Injected Air Quality and Pressure Regulation

Air put through the flow controllers shall be of sufficient quality so as not to adversely affect the flow controllers. Mine air is of sufficient quality if it is filtered using submicron coalescing filters or equivalent that are of sufficiently high flow-rate capacity to support the flow rate needed for testing. Place a filter between any regulating pressure reducer, if used, and the flow controllers to capture free moisture in the air to prevent it from contaminating the MFCs. Industrial grade or better, bottled air is an alternative to filtration. Filter or desiccate suctioned air from the rock if it is to be sent through an MFC. The pressure supplied to the MFCs and exiting from the MFCs shall be within the inlet and outlet ranges specified in the manufacturer's recommendations. Output pressure from the MFCs is a function of both tubing diameter and flow rate. The correct size MFC shall be used for a given flow rate. To obtain meaningful results, flow rates shall be chosen that that are high enough to yield a discernible pressure change in the injected or suctioned zone that is observable within the calibration specification of the pressure transducers but that does not compromise the seal of the packers. This choice may be made for particular tests using a trial and error basis or, alternatively, many flow rates may be attempted in an effort to bracket one or some of them to meet this criterion. The preparations performed for air quality, filter placement, and flow rates shall be documented in the scientific notebook.

3.5 Measurement and Test (M&TE) Equipment

The instruments that require calibration for air permeability testing are the MFCs, the pressure transducers, and any voltmeter used to measure the output from these instruments should they have analogue outputs. Each instrument shall be calibrated by a qualified supplier in accordance with YAP-12.3Q. A list of all this equipment, their serial numbers, calibration due date, each one's relationship to the data record (i.e., channel number) and each one's use in the test setup (e.g. location or zone in a borehole) shall be made in the logbook at the start of a set of tests.

If any out-of-calibration or out-of-tolerance conditions (as described in YAP-12.3Q) are determined to exist for any M&TE item or M&TE equipment used during a sequence of tests (i.e., calibration due date or interval has passed, equipment produces results known to be in error, or software or programmable hardware for the M&TE has been upgraded and dictates recalibration) the equipment shall have an out-of-service tag applied indicating that it is not to be used and, when possible, the equipment shall be moved to a segregated "out-of-service" area.

If M&TE that has not been calibrated or produces results known to be in error or is damaged in a way that affects calibration, has been used to collect data or gauge performance, document the out-of-calibration conditions by using the M&TE Out of Calibration Report in accordance with the instructions provided in YAP-12.3Q. If it is determined that the data is impacted, a Nonconformance Report (NCR) shall be initiated in accordance with YAP-15.1Q.

3.6 Data Aquisition

Record manually or electronically each permeability test with a start time, stop time, location and any other test parameters deemed appropriate by the operator or specified in this procedure. If done electronically, a description of the structure of this electronic record shall be included in the notebook. To describe the structure of a file a sample print of a representative subset of the type file being described with descriptive pointers to each of its components shall be included in the notebook. Every data point acquired by the acquisition system shall have a time, date, and location stamp assigned to it and be traceable to the calibrated equipment used to obtain it. Time and date on any electronic recording shall correlate with that used in the notebook. There shall be enough data points recorded during a test to enable proper interpretation of results as determined by the PI.

3.7 Testing Control

If the testing is under automatic control of any kind, describe in the scientific notebook, the function of the automatic controls and the projected sequence of automation for each set of tests. The actual sequence, whether implemented manually or automatically, shall also be recorded during testing in the notebook or electronically. If done electronically, a description of the structure of this electronic record shall be included in the notebook. To describe the structure of a file a sample print of a representative subset of the type file being described with descriptive pointers to each of its components shall be included in the notebook. By manually observing a representative sequence of equipment function under automatic control, verify in the notebook that the automation works as planned before the onset of testing.

3.8 Non-M&TE Function Verification

Before the start of each set of testing, verify that all equipment is functioning correctly with no leaks, blockages, crossed tubing or wires, shorts, or unintended open circuits. Check the data after testing to see if the values recorded are reasonable and to see if any valve or fittings in the system were obviously leaking or blocked. If possible, in setups where zones are isolated from high line pressure differences by means of valves, scan the data from high flow rate tests to determine if any non-injected or suctioned zones had significant pressure change due to leakage across a valve. A pressure change greater than that seen in the injection or suction zone indicates a failed valve at that particular non-injected or suctioned zone.

If there are determined to be any failures of equipment during a sequence of tests make an effort to determine when and where that failure occurred and at which point in time and for what parts of the testing corresponding data are invalid. Record this exact point and the affected parts of the data in the notebook or, barring successful determination of these, invalidate the data for the whole sequence of tests.

4. RECORDS MANAGEMENT

4.1 Lifetime

Records are entries in scientific notebooks and the electronic files associated with those entries. All relevant information to records shall be retrievable by reference to the notebooks.

4.2 Non-Permanent

None

4.3 Controlled Documents

This TIP

4.4 Records Center Documents

Records associated with this procedure shall be submitted to the Records Coordinator for transmittal to the Records Processing Center (RPC) in accordance with AP-17.1Q, *Record Source Responsibility for Inclusionary Records*.

5. RESPONSIBILITIES

5.1 The Principal Investigator (PI) is responsible for assuring full compliance with this procedure and providing training thereof. The PI is responsible for overseeing and coordinating TIP preparation, review, distribution, revision, and recommendation of rescission.

5.2 Staff Members involved in this activity are responsible for following this procedure and turning over related documentation to the Records Coordinator for submittal to the RPC in accordance with AP-17.1Q. Related data shall be turned over to the Technical Data Coordinator for submittal to the YMP Technical Data Management System (TDMS) in accordance with AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*.

6. ACRONYMS AND DEFINITIONS

6.1 Acronyms

AP	OCRWM Administrative Procedure
LBNL	Lawrence Berkeley National Laboratory
MFC	Mass Flow Controller
M&TE	Measuring and Test Equipment
OCRWM	Office of Civilian Radioactive Waste Management
PI	Principal Investigator

QIP	Quality Implementing Procedure
QSL	Qualified Suppliers List
RPC	Records Processing Center
SLPM	Standard Liter(s) per Minute
TIP	Technical Implementing Procedure
TDMS	Technical Data Management System
YAP	YMP Administrative Procedure
YMP	Yucca Mountain Site Characterization Project

6.2 Definitions

Packer:	Device with which to seal a borehole from outside air
Zone:	Sealed region in a borehole
Leak-by:	Air passing by a packer when it breaks seal with the borehole

7. REFERENCES

AP-17.1Q, *Record Source Responsibility for Inclusionary Records*

AP-SIII.1Q, *Scientific Notebooks*

AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*

DOE/RW-0333P, *Quality Assurance Requirements and Description (QARD)*

YMP-LBNL-QIP-5.2, *Preparing Development Plans & Quality/Technical Implementing Procedures*

YMP-LBNL-QIP-SV.0, *Control of the Electronic Management of Data*

YAP-12.3Q, *Control of Measuring and Test Equipment and Calibration Standards*

YAP-15.1Q, *Control of Nonconformances*

8. ATTACHMENTS

None

9. REVISION HISTORY

09/30/98 Revision 0, Modification 0:

This procedure is a derivative of a methodology described in J. Wang's Scientific Notebook YMP-LBNL-JSW 6.0.

01/21/2000 Revision 1, Modification 0:

Revised procedure to meet the YAP-12.3Q requirements, and incorporated references to current APs, YAPs, and QIPs. Deleted responsibilities for staff members not directly responsible for implementing this procedure.

10. APPROVAL

Signature on file

Preparer: Paul Cook — Date

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Technical Review: Barry Freifeld — Date

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Technical Review: Tim Kneafsey — Date

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EA Review: Nancy Aden-Gleason — Date

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